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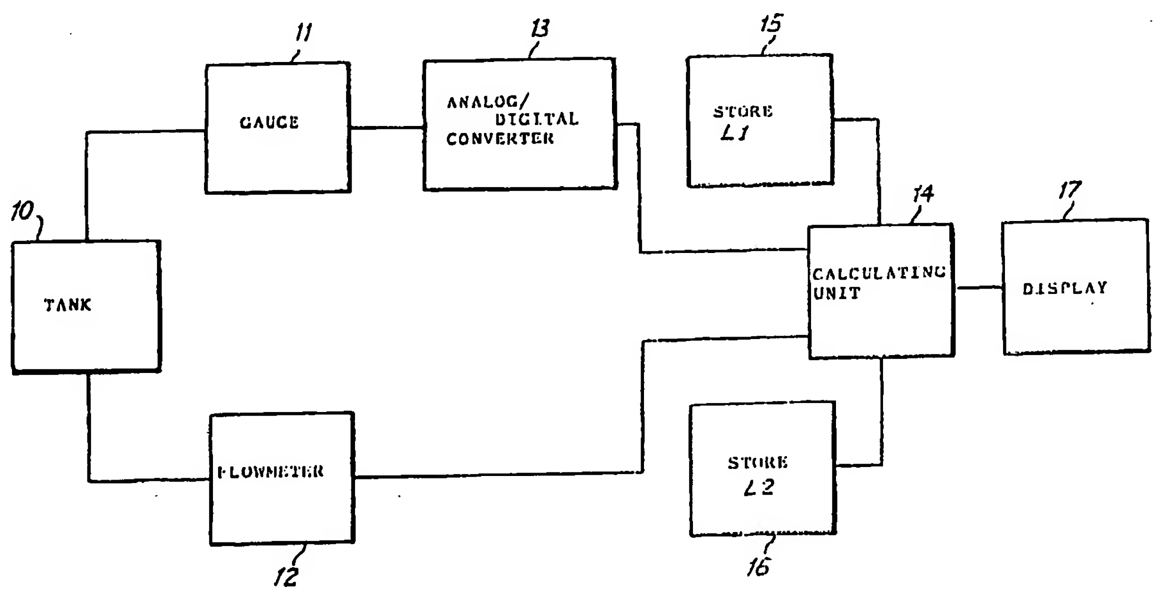
(54) Fluid measurement

(57) In measuring the amount of fluid contained in a tank (10), two values L_1, L_2 related to the amount of fluid present are calculated, from information provided respectively by a level gauge 11 and a flowmeter 12. A calculating unit 14 resets the second value when the difference between the two values exceeds a given threshold. Also, a factor applied to the flowmeter output is modified depending on the difference existing between the two values. The display 17 displays the second value L_2.

Fig. 1



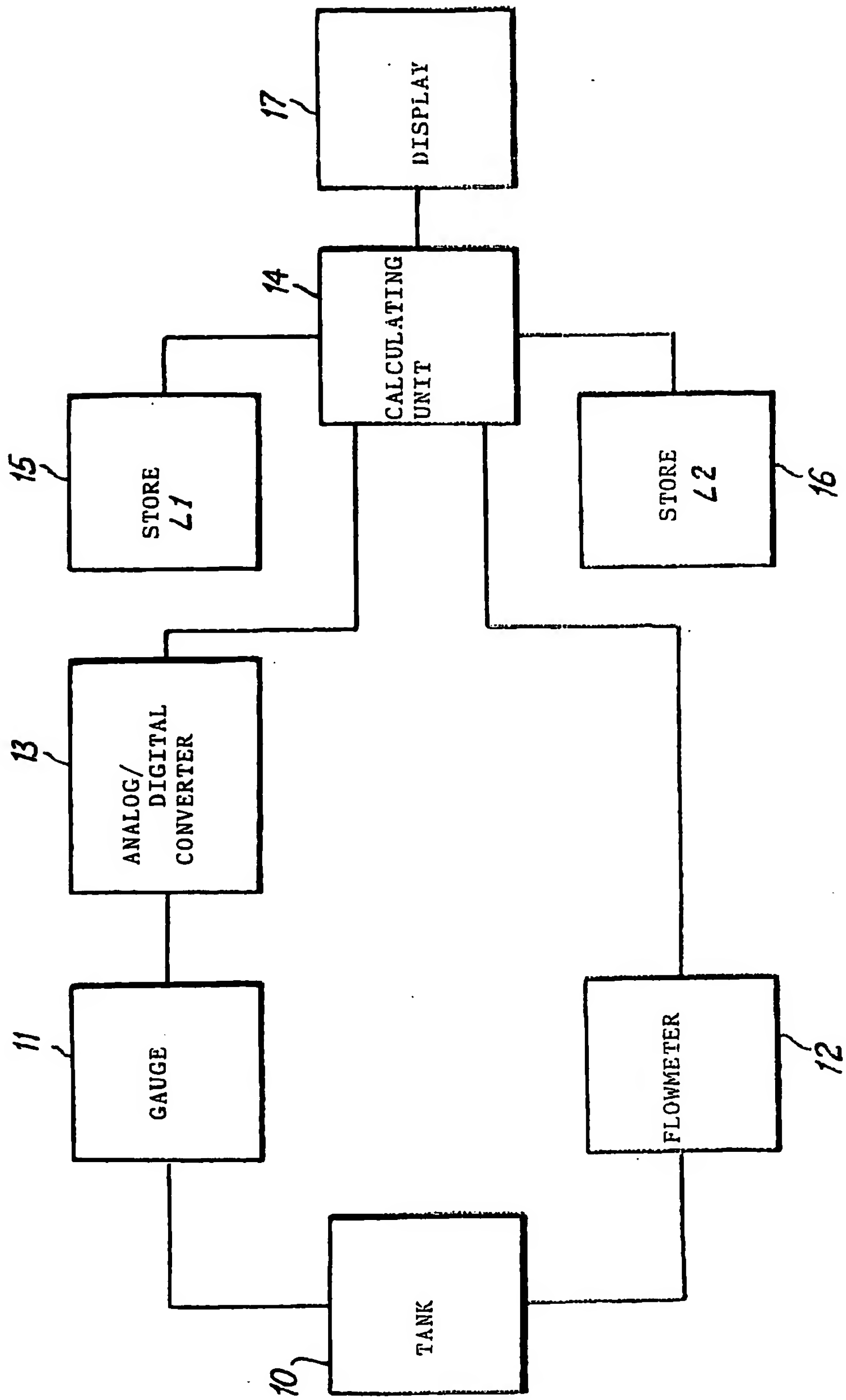

DISPLAY
17
CALCULATING UNIT
14
STORE L1
15
STORE L2
16
ANALOG/ DIGITAL CONVERTER
13
GAUGE
11
FLOWMETER
12
TANK
10

Fig. 1

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Fig: 2

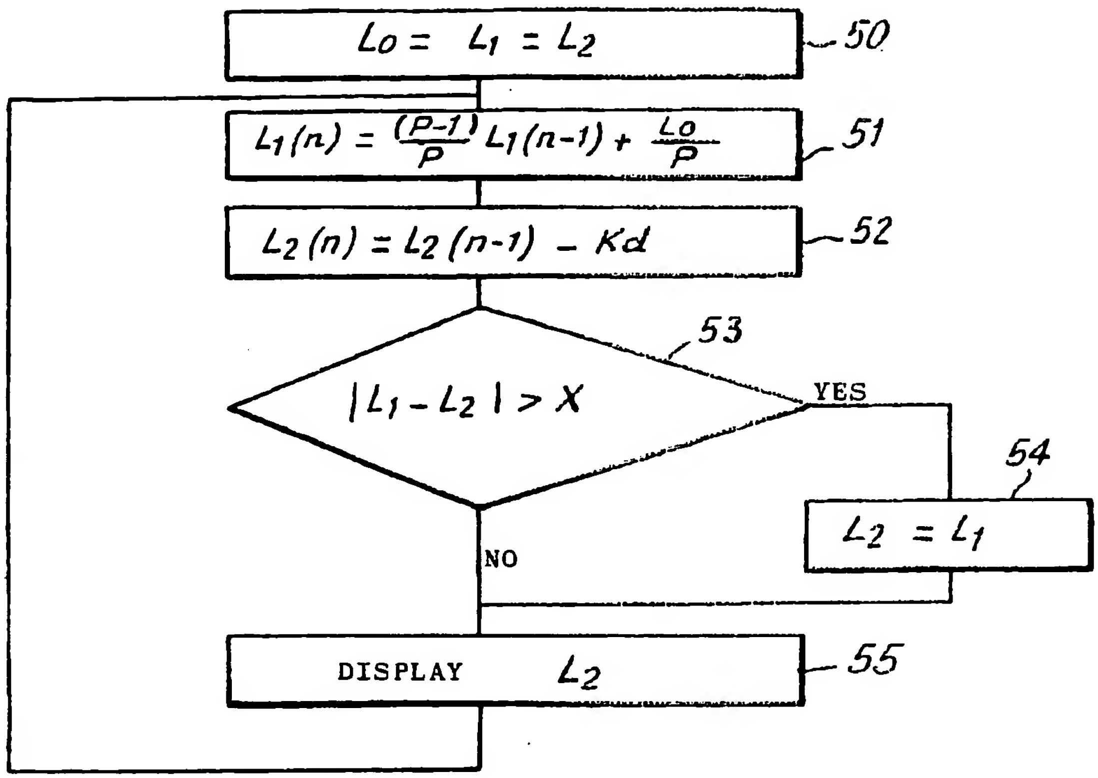

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Fig: 3

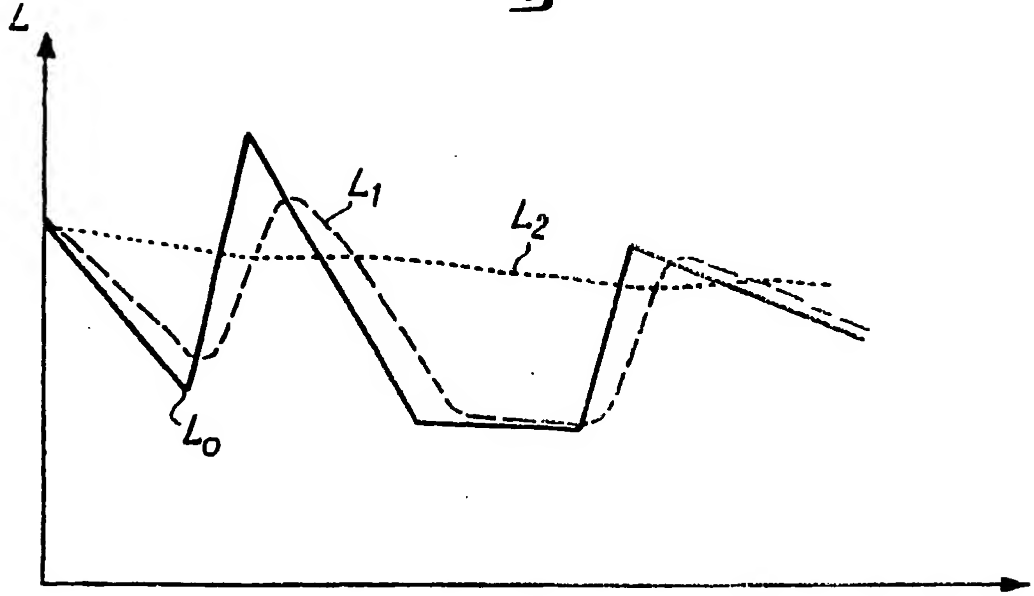


Fig: 4a

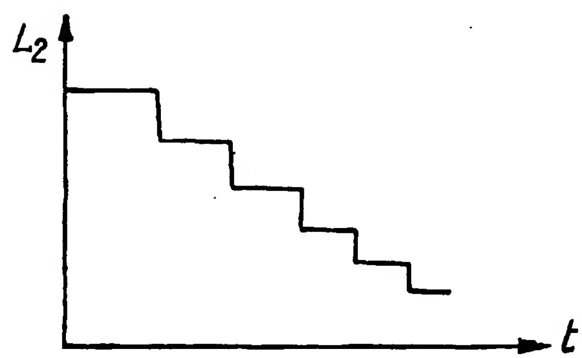
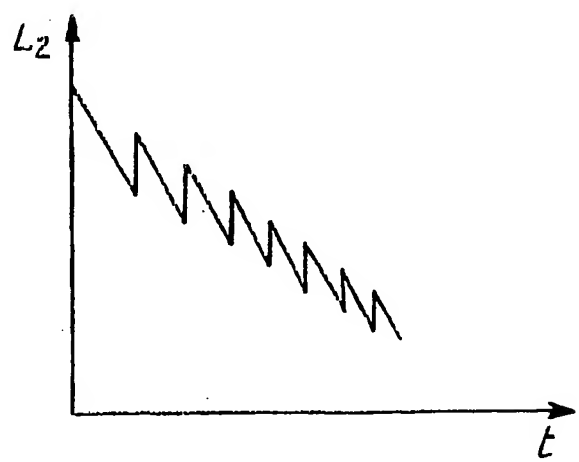


Fig: 4b



SPECIFICATION
Fluid measurement

The present invention relates to the measurement of the amount of fluid contained in a tank, particularly the amount of fuel present in the tank of a motor vehicle.

In the motor car field, the important development has been witnessed for some years of apparatus known as "car computers" which are intended to supply the driver with a large number of items of information, including average instantaneous consumption, cruising range, etc. Nevertheless, in order to ensure a correct operation of these apparatus and to facilitate the observation of these, it would be desirable to have available measuring systems which are precise and deliver stable information.

The more conventional devices for measuring the level of the fuel in the tank, such as devices with a float for example, cannot give satisfaction. Indeed, apart from problems associated with their complexity and poor reliability, these devices are very sensitive to the fluctuations in fuel level owing to disturbances, e.g. due to accelerations of the vehicle.

An attempt has been made to overcome this disadvantage by inserting the float in a tubular element which is disposed vertically and in communication with the tank through a calibrated orifice. Nevertheless, this arrangement proves relatively complex and it is found, in practice, that it does not provide sufficiently stable information.

Other devices have been proposed but these have been set aside particularly because of their high cost and technical complexity.

In accordance with this invention there is provided a method of measuring the amount of fluid contained in a tank, comprising:

(a) measuring the level of the fluid in the tank by means of a gauge,

(b) determining a first value $L_1(n)$ related to the amount of fluid present in the tank from a value L_0 representing the fluid level provided at a given moment (n) by the gauge and from a first value ($L_1(n-1)$) previously determined,

(c) measuring the amount of fluid withdrawn from the tank per unit of time,

(d) determining a second value L_2 related to the amount of fluid present in the tank from the measured flow rate, applying thereto a given factor (K);

(e) comparing the values L_1, L_2, related to the amount of fluid, as determined in steps (b) and (d);

(f) resetting the second value L_2 to equal the first value L_1 each time the difference between these two values L_1, L_2 exceeds a given threshold X, said second value (L_2) then representing the amount of fluid;

(g) modifying the factor K applied to the measured flow rate for the calculation of said second value (L_2) in the step (d) depending on the difference existing between the first value L_1 and the second value L_2; and

(h) repeating the steps (a) to (g).

The embodiment to be described herein is simple, robust, reliable and economical, while providing precise and stable information. In particular it makes use of a gauge and preferably a flowmeter, which devices are completely conventional in themselves. This embodiment enables the contents of the tank to be known in a precise and stable manner to supply the user of the car computer with stable information.

Other characteristics and advantages of the present invention will be apparent on reading the following detailed description with reference to the accompanying drawings, given by way of non-limiting example, and in which:

Figure 1 is a block diagram of a measuring device according to the present invention;

Figure 2 is a diagrammatic flow chart illustrating the operation of the device according to the present invention;

Figure 3 represents curves which illustrate the various values determined by the device according to the present invention; and

Figures 4*a* and 4*b* illustrate the value of the amount of fluid contained in the tank, as calculated by the device according to the present invention, in two particular cases.

As illustrated diagrammatically in Figure 1, the measuring device according to the present invention comprises a gauge 11 to measure the level of the fluid, or liquid, contained in the tank 10 of a vehicle, as well as a flowmeter 12 which measures the amount of fluid withdrawn from the tank per unit of time.

The information delivered by the gauge 11 is applied to a calculating unit 14 by means of an analogue/digital converter 13. Of course, it is easy to determine the number of litres of liquid contained in the tank 10, on the basis of the information delivered by the gauge 11, if the dimensions and the shape of the tank 10 are known.

In a similar manner, the pulses delivered by the flowmeter 12 and representative of the flow of fuel, are applied to the calculating unit 14. There again, it is possible to determine the number of litres of fuel contained in the tank 10 on the basis of the information supplied by the flowmeter, if the number of litres originally present in the tank 10 is known.

The measuring device according to the present invention likewise comprises two registers of stores 15 and 16, connected to the calculating unit 14. The first register 15 is adapted to store said first value (L_1) of the amount of fluid present in the tank, determined by means belonging to the calculating unit 14, depending on the information representative of the fluid level, delivered by the gauge 11, weighting this information on the basis of a first value previously determined.

The second register 16 is adapted to store a second value (L_2) of the amount of fluid present in the tank, determined by means likewise belonging to the calculating unit 14, depending on the

information (d) representative of the flow of fluid, delivered by the flowmeter 12, by applying a given factor (K) to this information.

As will be apparent on reading the following description, the calculating unit 14 likewise comprises means for comparing the aforesaid two values (L_1, L_2) of the amount of fluid and means for resetting the second value (L_2) when the difference between these values exceeds a given threshold, said resetting means making the second value (L_2) equal to the first (L_1) in such a manner that the second value represents the amount of fluid present in the tank. On the other hand, the calculating unit 14 comprises means for modifying the factor (K) applied to the information (d) delivered by the flowmeter 12 for the calculation of the second value, depending on the difference existing between the first (L_1) and the second value (L_2).

Finally, as illustrated in Figure 1, the device likewise comprises means 17 for displaying the second value L_2 representative of the amount of fluid present in the tank.

The method of measuring according to the present invention will now be described with reference to the flow chart illustrated in Figure 2.

When voltage is first applied and when the device is reset to zero, illustrated diagrammatically by the first step 50: "$L_0=L_1=L_2$", a value L_0 representative of the amount of fluid contained in the tank and calculated by the calculating unit 14 on the basis of the information delivered by the gauge 11 is transferred into the registers 15 and 16.

As illustrated by the step 51, the calculating unit 14 determines a first value $L_1(n)$ of the amount of fluid present in the tank depending on the information representative of the fluid level delivered at a given moment (n) by the gauge, weighting this information on the basis of a first value L_1 (n−1) determined previously. More precisely, as illustrated in Figure 2, the calculating unit 14 determines said first value L_1 on the basis of the following formula:

$$L_1(n)=\frac{(p-1)}{p}L_1(n-1)+\frac{L_0}{P}$$

in which:

$L_1(n)$ represents the first value L_1 at the moment n,

$L_1(n-1)$ represents the first value L_1 at the moment (n−1),

L_0 represents a datum proportional to the information representative of the fluid level delivered by the gauge,

p represents any whole number.

Said first value L_1, thus determined, is stored in the register 15 and reactualized sequentially, for example every second.

By way of non-limiting example, p may be equal to 16 which gives a response time equivalent to 16 seconds and causes a lag of 0.2 litre for flows of 50 litres/hour.

As illustrated in Figure 3, in which there is represented a first curve L_0 representative of the amount of fluid contained in the tank, determined on the basis of the information delivered by the gauge, as well as a curve L_1 representative of said first value, this smoothing effected by the calculating unit 14 eliminates the rapid variations in the values recorded by the gauge 11 and due, in particular, to the displacements and accelerations of the vehicle.

At the step 52, the calculating unit 14 determines a second value L_2 of the amount of fluid present in the tank depending on the information d representative of the flow of fluid, delivered by the flowmeter 12, applying a given factor K to this information d.

More precisely, the second value L_2 of the amount of fluid present in the tank is determined by the calculating unit 14 on the basis of the following formula:

$$L_2(n)=L_2(n-1)-Kd,$$

in which:

$L_2(n)$ represents the second value L_2 at the moment n,

$L_2(n-1)$ represents the second value L_2 at the moment (n−1),

d represents the information delivered by the flowmeter 12, representative of the flow of fluid,

K represents said factor.

At the step 53, the values L_1 and L_2 determined at the preceding steps 51 and 52 are compared. When the absolute value of the difference between L_1 and L_2 is greater than a given value X, the second value L_2 is reset in step 54, making it equal to the first value L_1.

Said second value L_2 is then representative of the amount of fluid contained in the tank 10 and this second value L_2 is displayed, in step 55, by the means 17. The method according to the present invention is then resumed before the step 51 in such a manner as to bring said first L_1 and second L_2 values representative of the amount of fluid present in the tank 10 constantly up to date.

Naturally, if the difference between the two values L_1 and L_2 is less than said constant X (step 53), the value of L_2 determined directly is displayed by the means 17.

By way of non-limiting example, the value X may be equal to

$$1+\frac{L_2}{20}.$$

Naturally, this value X may be selected differently.

Furthermore, as previously indicated, the method according to the present invention consists in modifying the factor K applied to the

information d delivered by the flowmeter 12, for the calculation of said second value L_2, depending on the difference existing between the first value L_1 and the second value L_2.

According to a first variant, said modification effected on the factor K applied to the information d delivered by the flowmeter 12 is effected as follows:

if the first value L_1 is lower than the second value L_2, the factor K is taken $=\alpha$K nominal, a relationship in which α is greater than 1 and, for example, $\alpha=1.3$.

whereas if the first value L_1 is higher than the second value L_2, the factor K is taken $=\beta$ K nominal, a relationship in which β is less than 1, for example $\beta=0.7$.

Such a smoothing prevents any rise of the second value L_2 and always tends to bring the second value L_2 closer to the first L_1, on the average. Of course, the values α and β can be easily determined for this purpose.

According to a second variant, the modification effected on the factor K applied to the information d delivered by the flowmeter 12 is carried out by taking the factor K=K nominal

$$\left(1+\frac{L_2-L_1}{L_2}\right)$$

a relationship in which:

L_2 represents the second value and

L_1 represents the first value.

According to a third variant, the modification effected on the factor K applied to the information d delivered by the flowmeter 12 is carried out by taking the factor K=K nominal

$$\frac{L_2}{L_1},$$

a relationship in which:

L_2 represents the second value and

L_1 represents the first value.

Finally, according to a fourth variant, the modification effected on the factor K applied to the information d delivered by the flowmeter 12 is carried out by taking the factor K=K nominal

$$[1+f(L_2-L_1)]$$

a relationship in which:

f (L_2-L_1) represents a function having the difference existing between the second value L_2 and the first value L_1 as a variable.

The contents of the register 16 are taken into account for the display, by the means 17, of the contents of the tank 10 and for the calculation of the cruising range.

In order to avoid the problems associated with the stopping of the engine and the opening of the electric feed circuit, it is possible to envisage transferring the contents of the registers 15 and 16 to permanent stores. Nevertheless, it is possible to provide that, when voltage is again applied to the circuit, the first measurement of L_0, determined on the basis of the information delivered by the gauge 11, is transferred to the registers 15 and 16, as an initial value of L_1 and L_2. Such an arrangement renders it possible, in particular, to take into account, in a simple and rapid manner, the sudden variations in the fuel level in the tank 10 which appear, in particular, when said tank 10 is filled.

As illustrated in Figure 3, in which the curve L_2 appears, if the gauge 11 is placed at a point where the level varies little with the inclination of the car, even if the fuel level varies with the waves, the display effected by the means 17 is effected with the precision of the gauge 11 and in a continually decreasing manner which is therefore not disturbing to the driver.

On the other hand, it appears that the various breakdowns liable to be encountered with the device according to the present invention can be simply traced. This if the level gauge 11 should be cut off, the indication delivered by the display means 17 would oscillate between two values corresponding substantially to the maximum level of the tank 10. Such a phenomenon is due to the fact that at the start, the gauge 11 indicates that the tank 10 is full. This indication is taken into account in the registers 15 and 16. The contents of the register 16 are brought up to date on the basis of the pulses delivered by the flowmeter 12, therefore the information delivered by the display means 17 tend to diminish substantially but is reset to the maximum value as soon as the difference between the registers 15 and 16 exceeds the aforesaid value X. In a similar manner, if the gauge 11 is short-circuited, the display means 17 indicate that the tank 10 is empty. Such a phenomenon is due to the registers 15 and 16 initially taking into account the information "tank empty" delivered by the gauge 11.

As illustrated diagrammatically in Figure 4a, when the flowmeter 12 is cut off or short-circuited, the information delivered by the display means 17 decreases in steps. Such a phenomenon is due to the fact that the contents of the register 16 are not continuously brought up to date on the basis of the information delivered by the flowmeter 12, because this is not delivering any pulses. The register 16 is therefore only brought up to date, in steps, when the difference existing between the register 15 and the register 16 exceeds the aforesaid value X.

Finally, as apparent in Figure 4b, when the flowmeter 12 delivers too great a number of pulses per cm^3 of fuel withdrawn from the tank 10, the information delivered by the display means 17 appears in the form of saw teeth. Such a phenomenon is due to the fact that the contents of the register 16 are reduced much more rapidly than the contents of the register 15. In such a case, when the difference between the contents of the register 15 and the contents of the register 16 exceeds the aforesaid value X, the

bringing up to date of the register 16 always tends to raise the value of this.

The flowmeter 12 may be replaced by any other suitable means capable of delivering information representative of the amount of fluid or fuel withdrawn from the tank per unit of time. By way of example, the flowmeter 12 could be replaced by an element sensitive to the number of revolutions of the engine or to the admission suction.

Claims

1. A method of measuring the amount of fluid contained in a tank, comprising:

(a) measuring the level of the fluid in the tank by means of a gauge,

(b) determining a first value $L_1(n)$ related to the amount of fluid present in the tank from a value L_0 representing the fluid level provided at a given moment (n) by the gauge and from a first value ($L_1(n-1)$) previously determined,

(c) measuring the amount of fluid withdrawn from the tank per unit of time,

(d) determining a second value L_2 related to the amount of fluid present in the tank from the measured flow rate, applying thereto a given factor (K):

(e) comparing the values L_1, L_2, related to the amount of fluid, as determined in steps (b) and (d);

(f) resetting the second value L_2 to equal the first value L_1 each time the difference between these two values L_1, L_2 exceeds a given threshold X, said second value (L_2) then representing the amount of fluid;

(g) modifying the factor K applied to the measured flow rate for the calculation of said second value (L_2) in the step (d) depending on the difference existing between the first value L_1 and the second value L_2; and

(h) repeating the steps (a) to (g).

2. A method as claimed in Claim 1, in which for step (c) a flowmeter is used.

3. A method as claimed in Claim 1 or 2, in which said first value L_1 is determined in step (b) according to the equation:

$$L_1(n)=\frac{(p-1)}{p}L_1(n-1)+\frac{L_0}{p}$$

in which:

$L_1(n)$ represents the first value L_1 at the moment (n),

$L_1(n-1)$ represents the first value L_1 at the moment (n−1),

L_0 represents a datum proportional to the value representative of the fluid level delivered by the gauge (11), and

p represents any whole number.

4. A method as claimed in any one of Claims 1 to 3, in which the second value related to the amount of fluid present in the tank is determined according to the equation:

$$L_2(n)=L_2(n-1)-Kd.$$

in which:

$L_2(n)$ represents the second value L_2 at the moment (n),

$L_2(n-1)$ represents the second value (L_2) at the moment (n−1), and

d represents the measured flow rate.

5. A method as claimed in Claim 4, in which the modification effected in step (g) of the factor K is carried out as follows:

if the first value L_1 is lower than the second value L_2 the factor K is taken as α K nominal, a relationship in which α is greater than 1,

whereas if the first value L_1 is higher than the second value L_2 the factor K is taken as β K nominal, a relationship in which β is less than 1.

6. A method as claimed in Claim 4, in which the modification effected in step (g) of the factor K is carried out by taking the factor K as K nominal

$$\left(1+\frac{L_2-L_1}{L_2}\right).$$

7. A method as claimed in Claim 4, in which the modification effected in step (g) of the factor K is carried out by taking the factor K as K nominal.

$$\frac{L_2}{L_1}.$$

8. A method as claimed in Claim 4, in which the modification effected in step (g) of the factor K is carried out by taking the factor K as K nominal

$$(\overline{1}+f(L_2-L_1)).$$

in which

$$f(L_2-L_1)$$

is a function of the difference between L_2 and L_1.

9. A device for carrying out the method as claimed in any one of Claims 1 to 8, comprising a gauge for measuring the level of the fluid contained in the tank, means for measuring the amount of fluid withdrawn from the tank per unit of time, and means for determining a first value $L_1(n)$ related to the amount of fluid present in the tank 10 depending on the information (L_0) representative of the fluid level, weighting this information on the basis of a first value $L_1(n-1)$ previously determined, further for determining a second value related to the amount of fluid present in the tank from the measured flow rate to which is applied said factor K, further for comparing the two values L_1, L_2, further for resetting the second value L_2 to equal L, when the difference between the values L_1, L_2 exceeds

a given threshold, and for modifying the factor K depending on the difference existing between the first and second values L_1 and L_2.

10. A device as claimed in Claim 9, in which said means for measuring the amount of fluid withdrawn from the tank is a flowmeter.

11. A device as claimed in Claim 9 or 10, comprising means for storing the first and second values L_1, L_2 and means for displaying the second value L_2 to represent the amount of fuel present in the tank.

12. A device as claimed in any one of Claims 9 to 11, in which said means for determining said first value L_1 is arranged to calculated the value

$$L_1(n)=\frac{(p-1)}{p}L_1(n-1)+\frac{L_0}{p},$$

in which:

$L_1(n)$ represents the first value L_1 at the moment (n),

$L_1(n-1)$ represents the first value L_1 at the moment $(n-1)$,

L_0 represents a datum proportional to the information representative of the level of fluid delivered by the gauge (11), and

p represents any whole number.

13. A method as claimed in claim 1 and substantially as herein described, for measuring the amount of fluid contained in a tank.

14. A device for measuring the amount of fluid contained in a tank, which device is substantially as herein described with reference to the accompanying drawings.

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